ART. 3.—*Memorandum on the Non-existence of "True Slates" in India generally, and, especially with reference to the Slabs of the Kurnool District, Madras Presidency, showing to what purposes they could be applied.* By T. OLDHAM, Esq., *Superintendent of the Geological Survey of India.*

[*Communicated by the Secretary of State for India, and read* 1st *June*, 1861.]

So far as known to me, or as I can gather from any information as yet published, there is no locality in India from which *true slates* have been obtained of any value. I use the term in the sense in which it is now universally used by geologists, as well as by architects and builders, to imply a rock of homogeneous texture, capable of almost infinite division into thin plates or slabs, splitting with tolerably even surfaces of considerable size.

This capability of such sub-division in all cases of true "slates" is the result of a structure superinduced in the mass of deposited matter which constitutes the rock, and is, in no case, the consequence of deposition originally in thin laminæ or layers. This structure has been produced by the action of several causes combined, the principal of which has been great forces of pressure exerted on the masses of the rock. It is quite unnecessary here to discuss the sources of this pressure; it is sufficient to notice the fact. A necessary consequence of this great pressure is, that where this capability of minute sub-division, or what geologists call "*cleavage*," exists in any perfection, the rocks are hard, close-grained, and, in most cases, as a consequence of this texture, durable. I would notice also that the perfection of this structure can only occur in a rock of homogeneous, or nearly homogeneous, texture, the surfaces of the planes of division deviating from their normal direction, or being deflected, when passing from one variety of material into another, and being at the same time less numerous, and less definitely marked in coarser materials, such as sand-stone, than in finer and more comminuted silt, or clays; and this in every possible degree.

Such is the character of true *slate*.

There are, at the same time, frequently met with beds or masses of rock which have been originally deposited in layers of great tenuity, or of very small vertical thickness, as compared with their horizontal extent. Such masses of rock are, naturally, easily divisible along the lines of these layers or laminæ, (marking, as they do, slight interruptions in the continuity of the deposition); and thus slabs, or thin plates of rock, are procured of varying size, which are frequently called slates, although not so in the true sense of the word.

It will be obvious, on considering for a moment the nature of deposition of silt, or other material from water, holding it in mechanical suspension, that the surfaces of such laminæ can never be expected to preserve for any great distance anything like true parallelism. The slightly greater amount of deposit in one place than in another, the varying strength of currents, the varying size of material held in suspension, all tend to produce irregularities, and unevennesses of surface; and such is, in reality, always found to be the case. Slabs may be, and often are, found of many square feet in superficial area, the thickness of which is small, and the two surfaces of which are nearly parallel; but a slab, taken perhaps from the immediately adjoining portion of the quarry, and from the continuation of the same layer, will differ very materially; and it will thus be found that no confidence can be felt in the permanence of such characters.

On the contrary, when the "cleavage" structure, of which I have spoken, is well developed, it is equally evident that, affecting as it does whole districts and mountain masses, it must have resulted from causes of such magnitude and extent, that the size of our very largest quarries becomes a mere point compared with the area over which such force has been exerted; and, therefore, a constancy, a permanency, and a regularity of result may fairly be looked for.

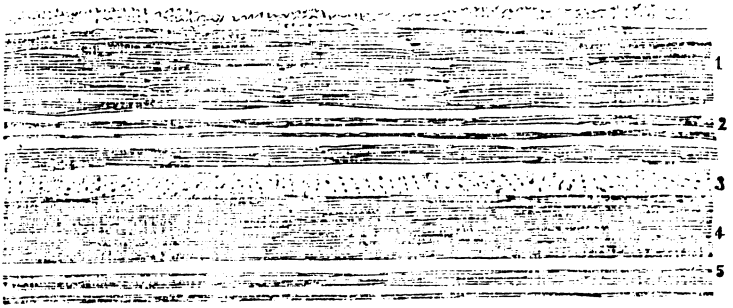
I have thought it desirable to notice these few general principles because it is evident, from the correspondence now referred to, as well as from much of a similar character, which has passed through my hands, this important distinction has been very generally and altogether overlooked.

The slabs referred to in this correspondence as used near Kurnool are not true slates. They are slabs derived from a fine-grained rock deposited in thin layers or beds, varying from 1 inch, or even less, to 5 and 6 inches, and more. This rock, when quarried in large masses, is readily divisible along the lines of deposition of

these laminæ into thin plates or slabs. And these slabs are, as stated, of sufficient thinness, and sufficient size, to form a material suitable for covering roofs or floors.

But these slabs are not procurable in such quantity, or of such a kind as to be useful in the same way as ordinary *slates* in Great Britain. In explanation of this I will briefly describe the way in which they occur, referring to no particular locality, but giving a *general* description.

Suppose a quarry to expose a section of ten to twenty feet in thickness of these beds. This section is probably made up of several distinct and well-marked layers of varying character, some more sandy, some more earthy, some fine-grained, some coarse. Here is a section which will give a *general* idea of such a quarry.



There are some five different beds; the top (No. 1) is, say, a thin-bedded rock, breaking up into layers or slabs of an average thickness of about 3 inches, some soft and comparatively useless, others harder and more durable; (No. 2) is a bed of slightly coarser material, also in layers, and divisible therefore into slabs, but of greater thickness, and a little more irregular; (No. 3) a sand-stone in one bed or layer, say 2 feet thick; (No. 4) thinly laminated, hard calcareous clay or shale, layers not more than one inch thick, and (No. 5) similar in composition and structure, but in layers of much greater thickness and irregularity.

Now it is obvious that out of the whole of this 20 feet in thickness there is only one bed which will give slabs of one inch thick (No. 4), and if such be required for roofs or other such purposes, the whole of the other beds must be removed before this one can be reached,—a mode of working which it need not be said cannot be economical. Or if thicker slabs be required for flooring, &c., the remainder of the beds in the quarry must be all removed to get at the beds yielding these. I here allude only to the division of the masses along planes of natural parting. I will have occasion

to show that any division by machinery will be too expensive ever to be employed largely.

With true slates this is not the case; the *same mass* can be almost infinitely sub-divided (the "cleavage" planes being produced *throughout* the mass); and *from the same mass* the thinnest and slightest slates, or the heaviest and strongest slabs, can be produced.

Even supposing, therefore, that slabs could be procured of size and thickness adapted for roofing (used in the manner of ordinary European slate roofs) the expense of such would necessarily be very great.

True "cleavage" has been, to a considerable extent, developed in the rocks of the Sikkim Hills, of the Kumaon Hills, and in other places; but in all cases that I am aware of, the rocks in which this structure is seen have not been originally homogeneous, and the consequence is that the planes of division, passing across the layers of different texture, are frequently, and indeed commonly, irregular. The thickness and consequent weight of the slates is a serious drawback to their use, while the small sizes in which they can be obtained render them highly objectionable.

Whether the material be thus divisible into true slates, as described, or only split into slabs of varying thickness, the modes of using such slates or slabs are principally two: either in flat pavements, floors, or coverings, whether these are to be external, and thus, roofs; or internal, as floors for rooms, verandahs, entrances, &c.; or 2ndly, as sloping or pitched roofs, as is ordinarily the construction of roofs in Great Britain and in Europe generally. Now the requirements of each form are so very different, that materials suited for one may be totally inapplicable to the other. Even the same material must be, for each of these forms, prepared in different ways.

For *floors*, or *flat roofs*, made or prepared in the ordinary way in which terraced or "pucka" roofs are prepared in India, (that is with the ordinary timbers and cross timbers between, on which latter are supported tiles, and a certain thickness of concrete or mortar beaten into a dense and water-tight mass)—for such floors, or roofs, slabs of slate or other stone may be used, and frequently with very great advantage, as a substitute for these tiles and concrete. In this case the advantages of such a material are its very much greater strength, and the consequent facility with which much larger squares or slabs may be used; so that the cross timbers instead of being placed at about one foot apart, may readily be used at double or even treble that distance, or may, if the material be

good, be dispensed with altogether, the slabs being laid directly on the beams. In this way the quantity of timber required in a roof or floor is greatly diminished, the joints in the floor are greatly fewer in number, and the probability of leakage therefore greatly less.

As a consequence of this, the thickness of the "pucka" or concrete covering may be greatly diminished, or, where the floor is properly constructed, may be dispensed with altogether. Consequent on this is another great advantage, that such a roof or floor will be much lighter than an ordinary "pucka" floor, and thus, besides the actual reduction in the number of the timbers, the scantling of those which will still be required may also be reduced.

For such uses the slabs must be obtained of the same general thickness; their edges must be sawn or ground truly square, so as to make fine joints; but if the mass be of tolerably even texture, the surfaces of natural division will require no great dressing further than the ordinary splitting.

The comparative value of slabs for such uses will depend mainly on the fineness of texture and state of induration of the rock, on which to a great extent the strength of the stone depends. And, as in this country (India), such materials are untried and unknown, it would be incumbent on every Engineer using such a material to test the strength beforehand, as well as determine the weight of the material. It is quite needless to suggest the methods of doing this; descriptions of such investigations are accessible to every one likely to be so engaged.[1] In Great Britain the average strength and weight of such materials is thoroughly established. For such applications also the absorbent or non-absorbent qualities of the stone become of essential importance, and ought to be tested. On this quality depends, to a great extent, the strength of the stone (a mass of stone, when saturated, being of little more than half the strength of the same mass when dry), and on this also depends the dampness and consequent coldness of the floor. The "weeping" of walls, so commonly complained of in parts of Great Britain, is entirely due to the use of compact and *non-absorbent* limestone, on the surface of which all the moisture of the air is condensed, and the same effect would result from the use of similar materials in this country. The comparative coldness, and also the

[1] A valuable series of experiments on the stone and timber of the Gwalior Territory was carried out by Colonel A. Cunningham and published at Roorkee. (Professional Papers, No. IV.—1854). These may be referred to as a model for other enquiries of similar kind.

slipperiness of such floors are disadvantages; but are easily overcome by the use of mats.

The use of iron girders or beams as joists, and such slate floors as I have just alluded to, will furnish an admirable means of obtaining a *fire-proof* building.

For *external* floors or roofs slate or thin slabs can be used in two ways:—1st, in a manner similar to that we have just noticed for floors, in which the same advantages are obtained, although to a greater extent than in floors; or 2nd, in the ordinary way in which slates are used in Europe.

As regards the former, any flat-bedded stone which can be readily divided into slabs sufficiently thin and strong will answer; in the second place it is essential that the stone should be divisible into slabs of great thinness, as compared with their size, and of great evenness of surface. This necessity arises from the mode of construction of the roof, in which the water tightness and absence of leakage is secured by lapping the edges of the slates so far one over the other that the ordinary capillary action, aided by the driving force of the wind, will not cause the rain-water to pass sufficiently under the over-lapping slates to reach the joints or division of that beneath. It becomes, therefore, essential that the slates should be of great thinness, as compared with their superficial area, or the roof becomes too heavy; and equally it is essential that the surfaces should be peculiarly smooth and even, so as to form a close joint, or, in other words, so that, when laid one on the other, the space between may be reduced to a minimum.

All these requirements are fully satisfied by the ordinary Welsh slates in common use in Great Britain. Slates of very many superficial feet in area can be readily procured, whose thickness does not exceed one-sixth to one-fourth of an inch, and with a variation in this thickness no where amounting to more than a small fraction of this thickness.

But I know nowhere in India where such can be procured.

The Government of Madras most justly remark that English slates are split, not sawn, and that sawing *might* make the material too costly. I think there can be no doubt on the subject; besides the expense, it would be impossible to saw slabs of sufficient size and tenuity, as neither would the material bear it, nor could it be had in sufficiently large masses without joints; the great weight also of such a roof, if constructed on the ordinary plan of sloping roof, would prove a most serious objection.

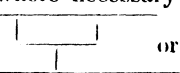
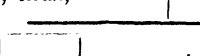
That slabs of stone, if properly selected, will be more durable

than tiles and mortar is, I think, clear; and that they will be more water-tight *ought* at least to be equally certain, for the joints through which alone the water *could* leak will be reduced to about one-tenth the number.

There is an objection to such external use of stone or slate for roof in India (if used without a covering of concrete or mortar) arising from the large amount of heat they absorb and again radiate. This, however, would be entirely obviated by a little increase in height of walls, or, in extreme cases, by the use of a boarding inside, or a lining to the roof.

I have little doubt, from the considerations alluded to above, that the Kurnool slabs referred to by Lieutenant Beckley and the Madras Government are entirely unfitted for sloping roofs; that they cannot be procured in slabs dividing naturally of such size and thickness as would adapt them for such roofs; that sawing them would, even if practicable, be too expensive; that the slabs thus procured would be either too thin to give the requisite strength, or, if of sufficient strength, would be too heavy and thick for economical or effective use. But for flat roofs or floors I think they may be used with advantage.

I would further urge that such stone slab floors, where the proper material can be procured with a moderate amount of carriage, and at a fairly reasonable rate, will prove much more durable, more economical, more cleanly, and in every respect better floors than either wood or "pucka" for Barracks, Hospitals, Court Houses, or any places where there is constant intercourse, and also for the verandahs of such buildings.

I have just alluded to the cleanliness of such floors; and I consider this to be by no means a trifling advantage. They can be mopped out with clean water or washed with soap and water in the same way as ordinary wooden floors, and can thus be kept sweet, clean, and free from vermin with the smallest amount of labour. The joints of the slabs should be ground or sawn true and set with asphalte; where necessary a small piece being let in over the joint, thus,  or if in external roofs, or floors, thus,  and laid in asphalte.

I may remark that Lieutenant Beckley does not state the size of the slabs which can be procured of one inch in thickness; but I would notice that the ordinary thickness of even the largest Welsh

slates is not more than one-fourth part of this. Nor is there any information as to the weight of the stone or its strength.

I would here strongly urge the great advantages which would result from a series of investigations in each District of the same nature as those valuable enquiries of Colonel A. Cunningham, to which I alluded above. Such investigations can only be undertaken with advantage, or with any fair prospect of success, by those who may be located in the neighbourhood for some time. But by none could they be conducted with greater advantage than by the able Officers of Engineers who are in charge of Districts, and who thus possess peculiar facilities for obtaining specimens, as well as information. I shall always be most happy to aid such investigations in any way in my power, by analysis of the materials or otherwise.

There are several localities in Bengal and the North Western Provinces where such slabs could be obtained as would be suited for flooring. The Hills to the south of Monghyr, the Sikkim Hills (poor), the Soane Valley, the Kumaon Hills, &c., &c., the Gwalior Hills. But in few cases will such materials admit of any great length of carriage; and they can, therefore, only be used economically when procured within a reasonable distance of the works where they are required.

6th August, 1860.